REMARKS

By the amendment, claim 1 is revised to place this application in condition for allowance. Currently, claims 1-4 are before the Examiner for consideration on their merits.

In review, claim 1 is revised to change the lower limits of Mn and Cr to 1.5% and 0.9%, respectively. Support for these changes can be found on pages 5 and 6 of the specification.

Turning now to the rejection, the Examiner maintains the rejection based on under 35 U.S.C. § 103(a) based on JP 5-202447 to Eiji et al. (Eiji), and has made a new rejection under 35 U.S.C. § 103(a) based on JP 407041856 to Kuriki et al. (Kuriki).

In light of the revisions to the claims and the other limitations found in the claims, it is submitted that neither Eiji nor Kuriki establish a *prima facie* case of obviousness. Alternatively, the discovery of the inventors relating to the ability to obtain high strength and toughness in a seamless steel tube having relatively low levels of carbon is an unexpected one that rebuts any contention of obviousness.

The traversal of the rejection is set forth below under the headings of the INVENTION, and the cited prior art references.

INVENTION

The invention is one that relates to the manufacture of seamless steel tubes for applications that require high strength, high toughness, and good weldability.

In the prior art, it is common to form seamless steel tubes using heat treating to attain the desired properties of high strength and high toughness. With the increased manufacturing costs due to heat treating, techniques were developed to make seamless steel tubes with the same properties but without heat treating. As explained on pages 1 and 2 of the specification, a number of approaches were taken to develop non-heat treated seamless steel tubes. One technique employed by the prior art was to have at least 0.2% C in the steel. However and as mentioned on page 2 of the specification, this level of carbon does not provide the needed toughness to go along with the achieved strength.

Other approaches included varying the carbon as in JP 2001-323338, but this approach still failed to attain the desired toughness. In yet another approach, variations in the manufacturing process were attempted, but these proved to be too costly due to the inability to use existing equipment and the need for an additional reheat of the material.

The present invention overcomes the drawbacks of the prior art by providing a non-heat treated seamless steel tube that exhibits both high strength and high toughness so that generating of cracking during welding is either prevented or significantly reduced.

The invention achieves this aim through the control of the composition of the seamless tube. That is, carbon is controlled to a content to be less than 0.17%.

Manganese is controlled in a range of 1.5 to 2.5%.

Chromium is controlled in a range of 0.9 to 2.0%.

Vanadium is controlled in a range of 0.03 to 0.3%.

The control of manganese, chromium and vanadium are important since the low level of carbon by itself results in a deterioration of strength and inability to provide a bainite-based metal structure.

The prior art does not recognize this advancement. Moreover, the artisan does not have the motivation to arrive at the claimed composition. In the alternative, the finding that high strength and high toughness levels can be attained with such low levels of carbon is unexpected given the prior art's desire of higher levels of carbon, and these unexpected results weigh in favor of the patentability of claim 1.

Eiji

In maintaining the rejection of claim 1 based on Eiji, the Examiner concludes that the upper limit of 0.17% C in claim 1 is sufficiently close to the lower limit of 0.2% in Eiji to establish a *prima facie* case of obviousness. The Examiner also concluded that the arguments of unexpected results were inadequate since Eiji disclosed steels that contained values with respect to tensile strength and toughness that were similar to those obtained using the invention.

Applicants wish to traverse the rejection based on Eiji in light of: (1) the revision to claim 1; (2) the fact that the values of Eiji are not similar to the values obtained according to the invention; and (3) the level of carbon in the claim is not the same or even similar to that disclosed in Eiji to support the rejection. It is also argued that the impact of Cr, Mn, and V must be considered with the low level of carbon in assessing the improvements of the invention, and the control of these elements and the results associated with such control is nowhere to be found in Eiji.

First, claim 1 now defines a level of Cr which is almost twice the upper limit of Eiji. That is, Eiji teaches a Cr range of 0.1 to 0.5%, whereas claim 1 now defines a lower limit of 0.9% Cr. The specification, see page 5, lines 12-15, and page 6, lines 5-7 and 14-17, teach that the control of Mn, Cr and V is important in achieving the balance of toughness and strength in light of the reduced amount of C in the claimed non-heat treated steel tube. Lacking overlap in Cr alone means that Eiji cannot establish a *prima facie* case of obviousness.

The claimed level of Cr in combination with the claimed levels of C, Mn, and V is critical in attaining the goal of the invention. Eiji, by its focus on the prior art levels of high carbon, i.e., greater than 0.2%, is off in another direction to solve the problem noted in Eiji's abstract of obtaining high strength and high ductility in a non-heat treated seamless tube. Given the difference in Cr and C levels, it is clear that Eiji's approach is not the same as that of the inventors, and these differences in alloying amounts and approach preclude maintaining the rejection under 35 U.S.C. § 103(a).

While the Examiner has alleged that the proximity of 0.17% C to the 0.20% of Eiji still supports an obvious contention, this stance cannot be taken with respect to the differences in Cr content between claim 1 and Eiji. As pointed out above, the claimed level of Cr is almost twice that of Eiji, and such a difference cannot be considered to be so similar that the two amounts are the same. Looking at Table 1 on page 4 of Eiji, comparative example 11 employs a chromium level of 0.52%, which is an indication that Eiji considers this amount to be sufficiently different from the upper limit of 0.50%. From this, it can only be concluded that a level of 0.9% Cr would clearly be outside the scope of the desired level of Cr for Eiji.

Moreover and as pointed out on page 6 of the specification, Cr successfully improves the strength of the claimed alloy without adversely affecting its toughness. In Eiji, the strength levels are attained through the use of much higher levels of C than used in the invention, and the levels of Cr are not even similar to those employed in the invention. Therefore, Eiji does not treat Cr with the same level of importance as the instant invention, and there is no reason why one of skill in the art would be motivated to alter the Cr content of Eiji so as to encompass that which is presently claimed. Any such allegation would be the impermissible use of hindsight to make an obviousness rejection.

Turning now to the Examiner's contention that a carbon content of 0.17% is indistinguishable from a content of 0.20%, Applicants contend that Eiji itself demonstrates this not to be true. The Examiner's attention is directed to Example 6 in Table 1 of Eiji. Here, the carbon content is 0.19%. Referring to Table 4 on page 6 of Eiji, properties for the composition of example 6 are shown as examples 6 and 6'. It should be understood that these examples are based on the composition of example 6 of Table 1, the difference being that one example has one physical form, e.g., a plate, with the other example having a different physical form, e.g., a pipe. For the Examiner's benefit, a machine translation of Eiji is submitted herewith to aid in understanding of the comparison made in Eiji. It is clear from Table 4 that the tensile strength for each example is 642 MPa and 643 MPa, which is inferior to the tensile strengths of the examples 1-5 according to the invention. Therefore, even if the Examiner could dismiss comparative example 26 of the instant application, consideration should be given to the comparison of Eiji, and the observation that a carbon content as low as 0.19% can affect the tensile strength performance of a non-heat treated seamless steel tube, and such is distinguishable from Eiji's target C content of 0.2% or more.

In this regard, the Examiner is also directed to the machine translation, paragraph [0014]. Here, Eiji teaches that levels less than 0.20% are not effective to secure reinforcement. This teaches two things. The first is that levels of carbon below 0.2% do affect the properties of the steel, and with this knowledge, one of skill in the

art would not consider a level of 0.17% C to be essentially the same as 0.20% of C. As importantly, Eiji teaches away from lowering the carbon level to below 0.20%.

The comparison in Eiji and the teachings regarding the criticality of the carbon content of 0.20% supports Applicants' contention that a level of C of 0.20% and that of 0.17% cannot be considered the same or even similar in the non-heat treated seamless steel tube art, and that Eiji does not establish a *prima facie* case of obviousness for this reason.

Given the teaching away of Eiji, one of skill in the art would not be motivated to lower the carbon content either and there is no basis to allege obviousness in this regard. In fact, the routineer would be led away from such a modification with Eiji's admonition of the drawbacks of lowering the carbon, and this teaching away is substantiation that the claims are patentable.

Applicants also take issue with the Examiner's observation that the properties of the tube of Eiji as expressed on page 6 thereof produce values that are similar to those of the invention. A close reading of these values reveals that the strengths of the materials tested in Eiji are not similar to those of the invention. Looking first at the inventive examples 1-21 in Table 1 of the specification, one example has a tensile strength of 719 MPa, with the remaining twenty examples exhibiting a tensile strength of over 756 MPa. Referring to the inventive examples of Eiji, one example has a tensile strength of 882 MPa, with the remaining eleven exhibiting a range between 703 and 734 MPa. Further, the very high tensile strength of example 2 can be attributed to the high C content of 0.39%, which is far in excess of the other C contents in Examples 1 and 3-5 of Eiji. Comparing the tensile strengths of Eiji and the invention, it can plainly be seen that the values are not similar. In fact, and excluding example 2 of Eiji, 11 out of twelve examples of the invention exceed the tensile strength attained by Eiji. What this means is that the prior art composition of Eiji is not so similar to that of Applicants that the Examiner can conclude that there is no patentable distinction between the two. To the contrary, the invention is not an obvious variation of the composition of Eiji. Instead, the invention provides advantages unforeseen by Eiji through the combination

of high tensile strength without a loss in toughness so that weld cracking is at the least minimized.

As a final point, the invention produces results that are not expected in light of the teachings of Eiji. As noted above, the prior art compositions having 0.2% carbon, which are akin to Eiji, could not provide the necessary toughness to accompany their high strength. This is particularly troublesome at a welding part which is hardened. Here the toughness is lowered and/or a welding crack is generated. This problem is solved through the control of C, Cr, Mn, and V. As a result of the control of these alloying elements in the claimed ranges, high strength is present, and, as importantly, high toughness is achieved, even at the welding part. This combination of properties is not taught by Eiji nor are they expected given Eiji's teachings. What is expected in Eiji is the problem noted in the specification, seamless tubes having C of 0.2% or more do not perform adequately in terms of strength, toughness and weldability. While it is argued above that Eiji does not establish a *prima facie* case of obviousness against claim 1, it is also contended here that any allegation is rebutted by the discovery that control of the ranges of C, Cr, Mn, and V can produce a seamless steel tube that has properties heretofore not found in the prior art.

In light of the above, it is respectfully asserted that the rejection of claim 1 and its dependent claims 2-4 is misplaced and must be withdrawn.

Kuriki

Kuriki discloses a method of manufacturing a high strength steel pipe having a composition as follows:

C: 0.15 - 0.4%

Si: 0.1 – 1.0%

Mn: 0.3 – 1.0%

Cr: 0.1 – 1.5%

Mo: 0.1 – 1.0%

P: not more than 0.015%

S: not more than 0.005%

B: 0.0005 – 0.003%

Al: 0.01 – 0.1%

N: 0.003 – 0.1%

One or two kinds of

Nb: 0.003 – 0.1%

V: 0.01 – 0.05%

Ti: 0.01 – 0.3%

In rejecting the claims, the Examiner alleged that Kuriki taught a composition that overlapped that which was claimed, and such overlap constitutes the establishment of a *prima facie* case of obviousness. Taking into account the changes made to claim 1, the Examiner cannot take the position that Kuriki overlaps the claimed composition.

More particularly, claim 1 defines a range of Mn of 1.5 to 2.5%. In Kuriki, Mn is limited to 1.0%. It is also noted in Table 2 of Kuriki that alloy B exhibits a Mn content of 1.6%. It is submitted that this is an error in the Table, and Kuriki cannot be interpreted to teach such a level of Mn for a number of reasons. First, Kuriki clearly teaches in the translated abstract a maximum level of 1.0% Mn. Viewing col. 1 on page 2 of Kuriki, the levels of Mn are consistent with the translated abstract, i.e., 0.3 – 1.0%. Lastly, alloy B in Table 2 corresponds to the inventive example, and using a level of 1.60% Mn as part of the inventive examples clearly conflicts with the remainder of Kuriki that suggests a maximum of 1.0% Mn. The only reasonable conclusion to draw from Kuriki is that the Mn content is limited to 1.0%.

It cannot be refuted that the Mn content of Kuriki does not overlap that which is claimed. Secondly, the upper limit of 1.0% of Kuriki is not sufficiently close to the claimed lower limit of 1.5% that the Examiner could still allege that the closeness of the values supports a contention that the range of 1.5 to 2.5% Mn in claim 1 is obvious over the teachings of Kuriki.

It should also be noted that Kuriki and the invention are unrelated since Kuriki does not teach a non-heat treated seamless tube. Kuriki teaches a seamless steel tube that is intended for use in the field of oil well or gas well applications as a result of the tube's excellent sulphide stress corrosion cracking resistance. In order to achieve this

property, the tube is subjected to accelerated cooling to complete its bainitic transformation, and then heated in the temperature range of the Ac3 transformation point to Ac3 + 100°C and hardened from the same temperature and then tempered at the Ac1 transformation point or below. This treatment produces a heat treated seamless steel tube, which is not the same as the non-heat treated seamless steel tube of claim 1.

In Kuriki, a bainitic structure is obtained by accelerated cooling before hardening and tempering. In contrast to Kuriki, the present invention processes the seamless steel tube by air cooling after rolling, see page 8, lines 17-19.

The Examiner cannot ignore the limitation that the claimed tube is a non-heat treated tube. As the Examiner knows, heat treating a seamless tube clearly imparts a structure to a material that would not be found in a tube that it not heat treated. Since the term "non-heat treated" limits the structure of the claimed tube, the Examiner must give this term weight in assessing patentability. When giving the term in question weight, the Examiner can only conclude that Kuriki does not teach a non-heat treated tube, and cannot be relied upon under 35 U.S.C. § 103(a) to further reject the claim.

Since Kuriki does not teach an overlapping composition with respect to claim 1 or even a non-heat treated seamless steel tube, this reference cannot establish a *prima facie* case of obviousness and the rejection must be withdrawn. In addition, there is no reason that one of skill in the art would alter the composition of Kuriki to include the specified manganese amount or totally alter the processing of Kuriki to produce a tube that is not heat treated. Any such contention can only be based on the Applicants' invention as a teaching template, and a rejection of this nature could not be sustained on appeal.

If the Examiner were to continue to assert that the invention is obvious in light of the teachings of Kuriki, the arguments made above with regard to Eiji and the unexpected results of the invention are reiterated here. That is, any allegation of obvious based on the teachings of Kuriki is effectively rebutted by the discovery that the control of the C, Cr, Mn, and V for the claimed non-heat treated seamless steel tube results in a combination of high strength and toughness and improved weldability.

In light of the above, it is respectfully submitted that Kuriki either does not establish a *prima facie* case of obviousness against claim 1 and its dependent claims or any such case is rebutted by the showing of unexpected results in the specification.

SUMMARY

By this response, it has been shown that neither Eiji nor Kuriki obviates the invention of claim 1 and there is no motivation to modify the prior art compositions or processing so as to arrive at the invention. Further, the improvements shown to occur rebut any contention of obviousness.

Accordingly, the Examiner is respectfully requested to examine this application in light of this amendment, and pass claims 1-4 onto issuance.

If the Examiner believes that an interview with Applicant's attorney would be helpful in expediting prosecution of this application, the Examiner is invited to telephone the undersigned at 202-835-1753.

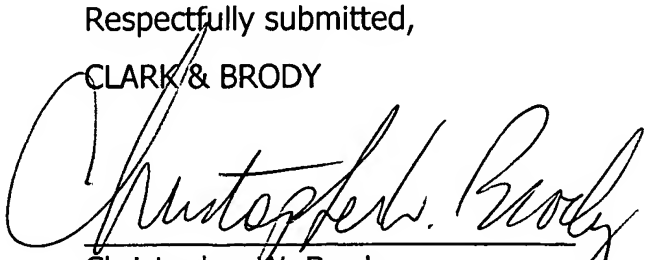
The above constitutes a complete response to all issues raised in the Office Action dated June 27, 2006.

Again, reconsideration and allowance of this application is respectfully requested.

A petition for a two month extension of time is made. A check in the amount of $450.00 is attached herewith. Please charge any fee deficiency or credit any overpayment to Deposit Account No. 50-1088.

Respectfully submitted,

CLARK & BRODY



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(54) SEAMLESS TUBE ON NON-HEAT-TREATED HIGH TENSILE STRENGTH STEEL FOR CYLINDER

(57)Abstract:
PURPOSE: To provide a non-heat-treated high tensile strength seamless steel tube for cylinder having high strength and high ductility in a as-hot-rolled non- heat-treated state, excellent in workability and weldability, and suitable for long-sized tube which is difficult to be heat-treated.
CONSTITUTION: The tube is a non-heat-treated high tensile strength seamless steel tube for cylinder having a composition which consists of, by weight, 0.20-0.45% C, 0.10-0.60% Si, 1.30-1.80% Mn, ≤0.040% P, ≤0.040% S, 0.005-0.05% Al, 0.10-0.50% Cr, 0.05-0.20% V, 0.005-0.020% Ti, 0.005-0.010% N, ≤0.010% Nb, ≤0.25% Cu, ≤0.30% Mo, and the balance Fe with inevitable impurities and where the carbon equivalent (Ceq) represented by C+Mn/6+Si/24 +Cu/5+Ni/40+Mo/4+V/14 is regulated to ≤ 0.65.

LEGAL STATUS

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[Date of sending the examiner's decision of rejection]	
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
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[Date of requesting appeal against examiner's decision of rejection]	
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* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] By weight %, for C Si 0.20 to 0.45% 0.10 - 0.60%, For P S 0.040% or less 1.30 to 1.80% 0.040% or less, [Mn] For Cr V 0.10 to 0.50% 0.005 to 0.05% 0.05 - 0.20%, [aluminum] For Ti N 0.005 to 0.020% 0.005 - 0.010%, Contain Cu for Nb and 0.30% or less is contained for Mo 0.25% or less 0.010% or less. Carbon equivalent expressed with
C+Mn/6+Si/24+Cu/5+nickel/40+Mo/4+V/14 (Ceq) Non-temper high tension seamless steel tubes for cylinders which are 0.65 or less and are characterized by the remainder consisting of Fe and an unescapable impurity.
[Claim 2] Non-temper high tension seamless steel tubes for cylinders according to claim 1 characterized by making C into 0.20 - 0.35% at a weight rate.
[Claim 3] Non-temper high tension seamless steel tubes for cylinders according to claim 1 or 2 characterized by making an austenitic grain size number or more into 6.5.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the non-temper high tension seamless steel tubes for cylinders suitable for the difficult long picture thing of heat treatment especially used in the state of un-adjusting [of a hot-working as] about the steel pipe for cylinders which operates with oil pressure etc.
[0002]
[Description of the Prior Art] As a steel pipe for cylinders of the hydraulic equipment used for an engineering-works construction equipment etc., the steel pipe which performed temper processing to carbon steel conventionally is used abundantly. However, obtaining a homogeneous thing over an overall length and all peripheries in temper processing needs careful cautions also for generating prevention of a knee necessarily easily.
[0003] Since in the case of heat-treated-steel tubing it is also problems that the manufacture time necessary for completion becomes long in addition to this and to become cost quantity and cutting ability is also further inferior, it is unsuitable for long material required as a long object for the cylinders of the stroke accompanying enlargement of a device in recent years, and the present condition is waiting for development of a new ingredient.
[0004] Moreover, as a non-temper high intensity hot-working steel pipe which such un-arranging does not produce, although 55kg class is specified to JIS, as a steel pipe for cylinders, a property is inadequate.
[0005] In addition, although non-temper high intensity hot-working steel materials are indicated by JP,55-138056,A, 56-38448, and 61-235541, neither is a thing about a steel pipe and it is related with the steel with which reinforcement differs from ductile level.
[0006] This invention is made in view of this situation, and it has high intensity and the Takanobu nature in the state of a non-temper with hot rolling, and workability and weldability are also excellent, and it aims at offering the non-temper high tension seamless steel tubes for cylinders suitable for the difficult long picture thing of heat treatment.
[0007]
[Means for Solving the Problem and its Function] It is a weight rate in order that this invention may solve the above-mentioned technical problem. C 0.20 - 0.45%, For Mn P 1.30 to 1.80% 0.10 to 0.60% 0.040% or less, [Si] For aluminum Cr 0.005 to 0.05% 0.040% or less 0.10 - 0.50%, [S] For Ti N 0.005 to 0.020% 0.05 to 0.20% 0.005 - 0.010%, [V] Contain Cu for Nb and 0.30% or less is contained for Mo 0.25% or less 0.010% or less. Carbon equivalent expressed with C+Mn/6+Si/24+Cu/5+nickel/40+Mo/4+V/14 (Ceq) It is 0.65 or less and the non-temper high tension seamless steel tubes for cylinders characterized by the remainder consisting of Fe and an unescapable impurity are offered. This invention is explained below at a detail.
[0008] Its reinforcement is high, and in order that hardening and tempering processing may make a detailed organization generate and may enable detailed distribution of carbide, they are heat treatment desirable for giving high toughness to steel. However, it is processing fairly difficult as mentioned above, and when processing especially long material, there are many problems.
[0009] Since non-heat-treated steel tubing used on the other hand with hot rolling has that processing workmanship temperature is high, that workability cannot necessarily take greatly, and a limit of a cooling rate, it is difficult for an organization to become big and rough and to secure both reinforcement and toughness.
[0010] Then, as a result of invention-in-this-application persons' performing various examination that the fault of such a non-temper hot rolling steel pipe should be conquered, it found out that what is necessary was just to adjust the presentation of an addition component and steel appropriately.
[0011] That is, by using a precipitation-hardening operation of V, the matrix potentiation of Mn and Cr, and strengthening and the quantity toughness-ized operation by addition of the suitable amount of aluminum, Ti, and N collectively, this invention persons have the reinforcement more than temper material and an EQC, and came to complete header this invention for the ability of high toughness-ization to be attained moreover.
[0012] The largest description on the alloy designing in this invention is V addition. By addition of V, detailed distribution of V carbide which has a matrix and adjustment during cooling arises from an elevated temperature, and reinforcement increases. However, if an addition increases, although reinforcement will carry out an increment according to it, toughness deteriorates. Then, the addition of V was restricted to the range which does not have a bad influence on toughness, and it decided to compensate reinforcement with Mn, Cr, etc. Especially Mn makes the minimum it is desirable and as high as 1.50% 1.30%. It is the element with which the effectiveness of Mn is assisted, Cr makes bainite increase, and since it has the operation to strengthen, addition of it is carried out 0.1% or more (about 0.2%) within the limit of 0.50%. In addition, although N, aluminum, and Ti also have some potentiation, the key objective of these addition is the high toughness-ized operation by detailed-izing of austenite crystal grain. This detailed-ized operation has high hot-working temperature, and workability is important for it especially in a comparatively low major diameter and a thick steel pipe.
[0013] In addition, it sets to a steel pipe and the property made into the target of this invention is 2 the 500Ns [/mm] yield point. It is 2 the tensile strength of 650Ns/mm above. It is in securing 50J% desirably desirably 20% or more of elongation

above more than V notch Charpy-impact-value 30J in 20 degrees C 30% or more (longitudinal direction JI No. 4 test piece). Next, the reason for limitation of each component is explained. In addition, in the following explanation, each % display shows weight %.

[0014] C is an element required in order to secure reinforcement. However, the effectiveness is not acquired as the amount is less than 0.20%, but if it exceeds 0.45% on the other hand, a degree of hardness will become high too much, and toughness also falls, and weldability also deteriorates, and a preheating is needed. Therefore, the amount of C is specified to 0.20 - 0.45% of within the limits. Moreover, in order to secure 30% of elongation, it is necessary to make it 0.35% of upper limits of C, and the range of desirable C is 0.20 - 0.35%.

[0015] Si is an element [required as a deoxidizer at the time of steel manufacture and] required also for reservation on the strength. However, toughness degradation will be brought about, if the effectiveness is not acquired at less than 0.10% but the amount exceeds 0.60% on the other hand. For this reason, the amount of Si is specified to 0.10 - 0.60% of within the limits.

[0016] Mn is the main strengthening element of this invention in V. However, if the amount becomes insufficient [less than 1.30% / reinforcement] and it exceeds 1.80% on the other hand, toughness will deteriorate. Therefore, the amount of Mn is specified to 1.30 - 1.80% of within the limits. Although there is relation with the amount of C, as for Mn, from a viewpoint which obtains sufficient reinforcement, it is desirable that it is 1.50% or more.

[0017] Since both P and S are elements which embrittle steel, they specify each of these amounts to 0.040% or less. It is desirable to make each to 0.020% or less from a viewpoint which secures toughness.

[0018] Cr is an element which makes a matrix strengthen. However, less than 0.10% of the amount is not enough as the effectiveness, and, on the other hand, the effectiveness tends to be saturated at about 0.50%. Therefore, the amount of Cr is specified to 0.10 - 0.50% of within the limits. The usual addition of Cr is about 0.20%.

[0019] Although aluminum is a deoxidizer, it combines with N in steel, is set to AlN, and has the operation which makes crystal grain detailed. However, when there are few those amounts than 0.005%, if this effectiveness cannot be expected and it adds exceeding 0.050%, degradation of toughness will be imitated on the contrary, and it is **. Therefore, the amount of aluminum is specified to 0.005 - 0.050% of within the limits.

[0020] Ti has the operation which deposits as TiN like aluminum and makes austenite crystal grain detailed. Toughness improves by this and reinforcement increases. The effectiveness is accepted from 0.003% and the inclination saturated with 0.020% has it. Therefore, the amount of Ti is specified to 0.003 - 0.020% of within the limits.

[0021] N has the operation which coexists with aluminum and Ti and makes the above-mentioned crystal grain detailed. However, if the effectiveness is not clear and exceeds 0.010% on the other hand when there are few the amounts than 0.0050%, a mechanical property will deteriorate. For this reason, the amount of N is specified to 0.0050 - 0.010% of within the limits. The austenitic grain size number of a steel pipe can be used as the fine grain beyond No.6.5 by maintaining the amount of aluminum, Ti, and N within the limits of above-mentioned.

[0022] V is a main element for securing reinforcement and toughness, as mentioned above. However, if reservation on the strength is difficult for the amount at 0.05% or less and it exceeds 0.20%, toughness will also deteriorate. Therefore, the amount of V is specified to 0.05 - 0.20% of within the limits.

[0023] In addition, although each of Nb(s), Cu(s), and Mo is impurity elements, 0.010% or less, 0.25% or less, and 0.30% or less of content is permitted respectively. When adding these too much, Nb is harmful to toughness, Mo is harmful to weldability, and since Cu is harmful to hot-working nature, it restricts the amount of these elements within the limits of the above. Moreover, although nickel also usually contains about 0.15% as an upper limit as an impurity element, even if nickel contains exceeding this amount, it does not have a property top bad influence. In addition to limitation of the component shown above, the carbon equivalent Ceq given by the following formulas (each element is weight %) is restricted to 0.65 or less from a viewpoint which keeps weldability good.

Ceq= 4+V [C+Mn/6+Si/24+Cu/5+nickel/40+Mo/]/14 [0024]

[Example] The steel which has the component and presentation of the numbers 1-5 shown in Table 1 was ingoted, and the steel pipe with an outer diameter [of 323.8mm] and a thickness of 18.5mm was manufactured after manufacturing a billet with Mannesmann punching, mantle rel mill rolling, or plug mill rolling. In addition, these numbers 1-5 are the examples of this invention within the limits. Among Table 1, numbers 6-11 are examples of a comparison from which it separates from the range of this invention, and were made into the plate which gave the same temperature-increase-by-plastic-working hysteresis as the case of rolling of a steel pipe and a steel pipe (the steel pipe was manufactured on the same conditions as an example only about numbers 6, 7, and 8, and it considered as number 6', 7', and 8' in Table 4 mentioned later). In addition, about the steel of a number 3, the steel pipe of the size shown in Table 2 was also manufactured (numbers 31-33). Moreover, the plate which gave various temperature-increase-by-plastic-working hysteresis about the steel of a number 3 as shown in Table 3 was produced (number 3A - 3D).

[0025]

[Table 1]

番号		成分（重量%）																Ceq	オーステナイト結晶粒度番号
		C	Si	Mn	P	S	Ni	Cr	Al	N	Cu	Mo	V	Ti	Nb		
実施例	1	0.20	0.15	1.75	0.019	0.018	0.03	0.45	0.02	0.009	0.20	0.2	0.10	0.005	0.005	0.45	6.5
	2	0.39	0.11	1.30	0.008	0.005	0.03	0.12	0.005	0.006	0.03	0.0	0.06	0.020	0.001	0.64	7.5
	3	0.29	0.55	1.50	0.009	0.000	0.14	0.24	0.03	0.004	0.03	0.01	0.08	0.004	0.001	0.62	7.0
	4	0.32	0.35	1.52	0.016	0.018	0.03	0.15	0.01	0.007	0.05	0.05	0.11	0.011	0.007	0.64	7.0
	5	0.28	0.33	1.51	0.011	0.040	0.03	0.20	0.05	0.009	0.15	0.05	0.10	0.005	0.001	0.61	7.0
比較例	6	0.19	0.36	1.42	0.009	0.008	0.03	0.05	0.01	0.007	0.03	0.05	0.12	0.010	0.001	0.48	8.0
	7	0.48	0.30	1.40	0.009	0.009	0.03	0.15	0.01	0.007	0.03	0.05	0.07	0.011	0.005	0.78	7.5
	8	0.30	0.65	1.85	0.008	0.000	0.03	0.15	0.01	0.007	0.03	0.05	0.12	0.009	0.015	0.69	7.0
	9	0.29	0.34	1.35	0.009	0.007	0.03	0.21	0.08	0.009	0.03	0.02	0.25	0.005	0.025	0.60	7.0
	10	0.29	0.09	1.25	0.051	0.042	0.03	0.21	0.003	0.004	0.03	0.03	0.04	0.002	0.020	0.56	7.0
	11	0.26	0.08	1.26	0.009	0.009	0.21	0.52	0.01	0.015	0.30	0.35	0.11	0.025	0.003	0.68	7.0

invention example

comparative example

[0026]
[Table 2]

番号	外径 (mm)	肉厚 (mm)	オーステナイト結晶粒度番号
31	134.8	25.0	6.5
32	244.5	16.0	7.5
3	323.8	18.5	7.0
33	355.6	25.0	7.0

[0027]
[Table 3]

番号	圧延開始温度 (℃)	加工度	オーステナイト結晶粒度番号
3A	1100	2. 0	5. 5
3B	1100	2. 5	6. 0
3C	1100	3. 0	6. 5
3D	1150	3. 0	5. 0

[0028] As for the steel of the number 6 of the example of a comparison, C a minimum, as for the steel of a number 7 in addition, an upper limit [C and Cr] the steel of a number 8 -- Si, Mn, and Nb -- an upper limit -- the steel of a number 9 -- aluminum and V -- an upper limit -- the steel of a number 10 -- Si, Mn, aluminum, N, V, and Ti -- a minimum -- P, S, and Nb -- Si and Mn satisfy a minimum and, as for the steel of a number 11, Cr, N, Cu, Ti, and Mo have not satisfied the upper limit for the upper limit, respectively. Furthermore, as for numbers 7, 8, and 11, the carbon equivalent Ceq is over 0.65.
[0029] After each steel pipe heated the billet at 1200 degrees C or more, as mentioned above, it was manufactured with Mannesmann punching, a plug mill, or mantle rel mill rolling. Processing workmanship temperature is about 1000 degrees C, and workability between 1100-1000 degrees C which has big effect on an austenite grain size was set to about 3.0.
[0030] When the plate of number 3A - 3D heated the steel of a presentation of a number 3 at 1200 degrees C, cooled and became 1100 degrees C and 1150 degrees C, it started rolling. Workability was set to 2.0-3.0. Each plate of the numbers 6-11 of the example of a comparison is 1200-degree-C heating and 1100-degree-C rolling initiation (1000-degree-C termination) workability 3.0. A mechanical property is shown in Table 4. As mechanical characteristics, the yield point, tensile strength, elongation, and the V notch Charpy impact value in 20 degrees C were evaluated.
[0031]
[Table 4]

番号		試料	降伏点(耐力) (N/mm^2)	引張強さ (N/mm^2)	伸び (%)	シャルピー衝撃値(20℃) (J)
実施例 (inventive example)	1	管	509	703	38.1	53
	2	管	594	882	27.0	52
	3	管	512	719	37.2	61
	31	管	507	712	37.0	60
	32	管	513	734	36.8	59
	33	管	512	717	38.7	58
	3A	板	504	710	39.1	42
	3B	板	507	710	38.2	46
	3C	板	510	719	37.5	63
	3D	板	502	707	39.0	41
	4	管	511	712	36.9	63
	5	管	507	704	37.8	59
比較例 (comparative example)	6	板	479	642	43.2	68
	6'	管	481	643	41.0	62
	7	板	616	852	19.1	42
	7'	管	615	845	19.5	40
	8	板	509	762	25.1	24
	8'	管	543	760	24.2	22
	9	板	511	720	34.1	29
	10	板	491	690	32.9	27
	11	板	487	686	30.2	24

tensile strength

plate

pipe

[0032] It was checked that the good result with which each of steel pipes of numbers 1-3, 31-33, and 4 and 5 was satisfied of the previous target is obtained. Reinforcement was insufficient for a number 6 and 6' among the numbers 6-11 of the example of a comparison, and it was checked that numbers 7-11 and 7' run short of toughness. Although number 3A - 3D were as a result of the plate, as for 3A and 3B with the small austenite grain size No. and 3D, it was checked that toughness tends to become low.

[0033] In addition, after processing it into a cylinder, the seamless steel tubes for cylinders performed the weld examination about the steel pipe of numbers 1-5 and 6' - 8' in order to usually weld piping etc. Consequently, although welding without a crack was attained in numbers 1-5 and 6', the crack occurred in number 7' and 8'.

[0034]

[Effect of the Invention] According to this invention, it has high intensity and the Takanobu nature in the state of a non-temper with hot rolling, and workability weldability is also excellent, and the non-temper high tension seamless steel tubes for cylinders suitable for the difficult long picture thing of heat treatment are offered.

[Translation done.]